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## HOME RANGE OF ELEPHANTS IN FRAGMENTED HABITATS OF CENTRAL INDIA<sup>1</sup>

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(With four text-figures)

**Key words:** home range, range fidelity, habitat, degradation, fragmentation, central India.

Home range of three adult bulls and one adult female (and her clan which included her family unit and associated family units) living in Dalma Wildlife Sanctuary, Bihar were studied from 1989-1992. All animals were identified visually and their locations were digitized and analyzed using Spacial Ecology Analysis Program (SEAS). One bull represented the resident population of 16 elephants, whereas the remaining two and the female represented migratory population of 50 elephants.

Analysis of home range pattern showed that considerable part of home range of all the individuals of the whole population lie outside the sanctuary limits. The home ranges expanded to the maximum in winter and shrunk to minimum in summer. The expansion was always along the long axis of home range. The resident population expanded the home range towards west and to a lesser extent towards north and the migratory population to the east. Existing traditional routes might be one of the factors influencing such directional expansions. Knowledge of home ranges of elephants, especially in fragmented areas, could be a key to solve many problems associated with elephant management.

### INTRODUCTION

The ranging behaviour of elephants has been studied in different parts of Africa and Asia. The African studies were started by Douglas-Hamilton 1973, 1975, Leuthold and Sale 1973, Leuthold 1977b, Merz 1986a, Dunham 1986, Hall-Martin 1987, Viljoen 1989, and mainly described the size of the home range in relation to environmental factors, vegetation,

shape and spatial distribution. The fidelity to the home range was studied by Wyatt and Eltringham (1974), Leuthold (1977b), and Viljoen (1989).

In Asia, home ranges were studied by Khan 1967, Olivier 1978, Sukumar 1985, 1989a, 1989b; Easa 1988, and Desai 1991. Olivier (1978) studied home ranges of elephants in Malaysian primary and secondary rain forests. Easa (1988) carried out similar studies in forests of Kerala state. Sukumar (1985, 1989a, 1989b) estimated home ranges of clans and bulls in the eastern ghat area, using Minimum Convex Polygon method. Management issues like identification and maintenance of corridors that

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link sub-populations were studied by Desai (1991).

A review of the literature on the ranging pattern of elephants reveals that information on home ranges of elephants in fragmented areas, where the habitat was/is rapidly lost to urban development and was/is continuously degraded, is not available. In India, there is no protected area for elephants as small as Dalma Wildlife Sanctuary (193 sq. km), having heavy biotic pressure. The Chandka Wildlife Sanctuary in Orissa is also as small but with negligible biotic pressure at the present. The ranging of elephants in such a habitat as Dalma has an additional component of seasonal migration of 75 % of the population to the plains of West Bengal for 5 to 6 months of the year. Therefore, it was important to study home ranges and of elephants in the fragmented areas for better management planning.

The objectives were:

1. To find the size and extent of home ranges of some identified elephants of the Sanctuary.
2. To determine the fidelity of the individual animals to their home ranges.
3. To ascertain the factors influencing the size of the home ranges.
4. To estimate the overlaps of the individual home range and the Sanctuary, i.e. to find how much of the home range lies outside the Sanctuary, in agricultural land, and inside the Sanctuary.

#### STUDY AREA

The study was undertaken in Dalma Wildlife Sanctuary and surrounding elephant areas of the Chhotanagpur Plateau in the state of Bihar and in the migration range of elephants of the Singhbhum district into the plains of West Bengal. The major elephant ranges in Bihar

other than the Dalma Wildlife Sanctuary are Palamau National Park, Porahat, Kolhan, Saranda, Roam and Mosabani reserved/protected forests, most of which are fragmented and severely degraded. The Dalma Wildlife Sanctuary is spread between 22° 5.30' N to 22° 57' N and 86° 7' E to 86° 20' E on the Chhotanagpur plateau in south Bihar and it is adjacent to the tri-junction of borders of the states of Bihar, Orissa and West Bengal (Fig. 1). The range of elephants of Dalma Sanctuary extends into plains of West Bengal covering parts of Purulia, Midnapur, Bankura, and to a lesser extent Bardhaman and Hoogli districts. In Bengal the natural forests exist only in small patches of few hectares mainly in the western part adjoining Bihar. Most other forest patches consist of sal monoculture that are in a state of severe degradation, though in some places there are signs of recovery due to protection provided by local villagers. The essential feature in the physical aspect of the elephants' habitats in Bihar, is the prevalence of plateaux and hills, often rising into mountains which rarely exceed 1000 metres in elevation. The forest of Dalma belongs to a unique *Shorea-Cleistanthus-Croton* series (Gadgil & Meher-Homji 1986). The Champion-Seth classification shows the forest as consisting of dry peninsular hill sal, and northern mixed dry deciduous type. The forests of the Chhotanagpur plateau exhibit a variety of habitat types ranging from dry deciduous to evergreen though the study area constituted only dry deciduous type of forest. The whole study area being a tribal belt is inhabited by several different tribes, each having a distinctive tradition, language and culture. The area is extremely backward in spite of being the most mineral rich area of India, producing copper, uranium, iron ore, coal, gold and many other important minerals. In fact this area generates a fourth of the total mineral produce of the



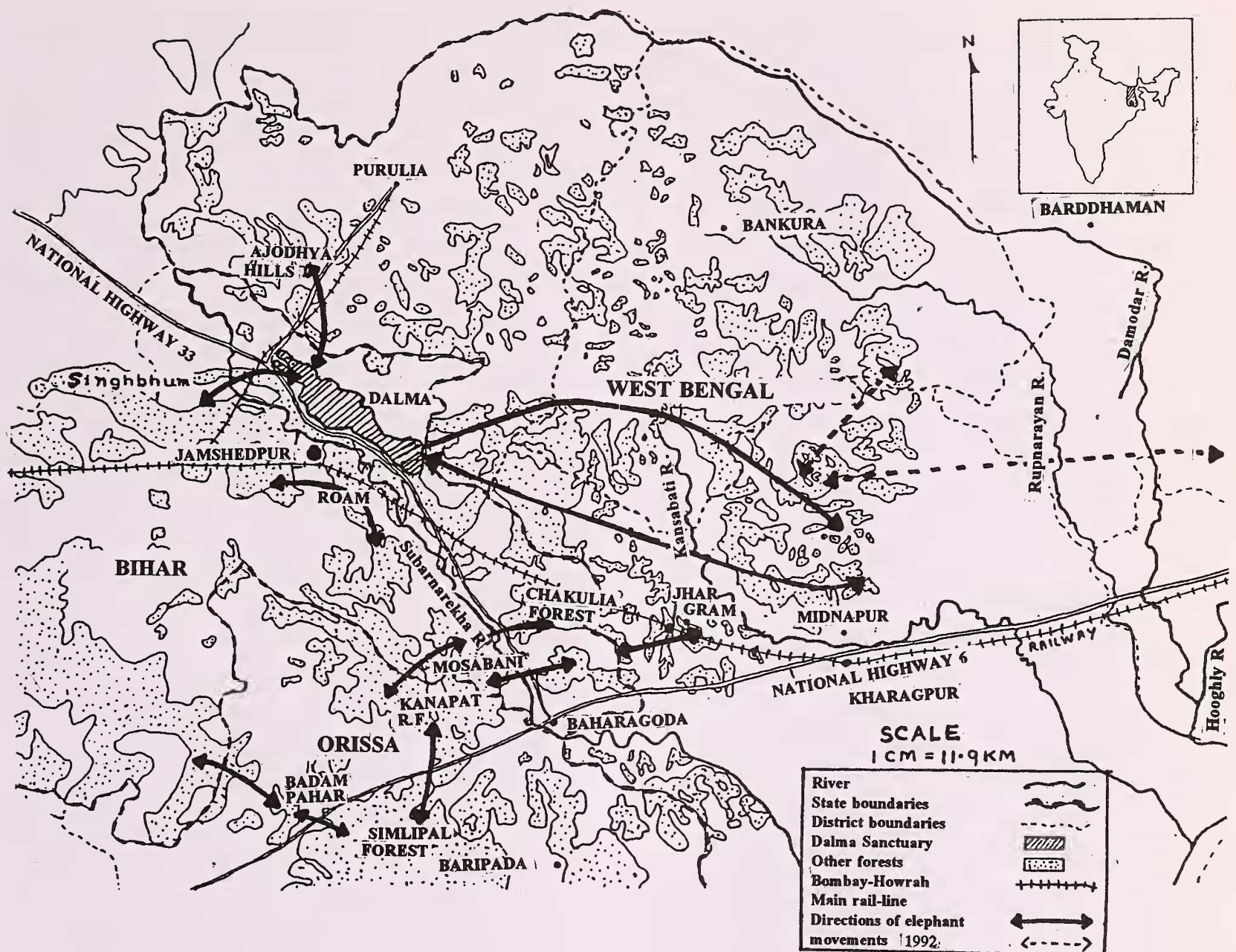


Fig. 1. Location of the study area and general directions of movement of Dalma Sanctuary elephants.

country. However, it lacks in basic amenities like medical facilities, education, potable water supply, electricity, transport and education in most places. The rapid industrialization due to the presence of vast deposits of a variety of minerals has resulted in economic disparity between the urban 'outsiders' and the tribals. Since 1914, the tribals of the plateau have been demanding an independent tribal state called 'Jharkhand' and the agitation has/had taken violent turns in the last and the present decade. The anger against the ruling government was often redirected towards the state owned forests, by felling the trees indiscriminately. The forests

of the area which were rich in flora and fauna are giving way to mining activities in many places and almost all the forests are under various degrees of biotic pressure. This has resulted in shrinking and degradation of the elephant habitat, forcing elephants to move out of the traditional habitat, to raid crops to meet their energy requirements and to seek better habitat elsewhere.

#### METHODOLOGY

The ranging behaviour of elephants has been studied through different methods. In

Africa, visual resightings of identified individuals was used to determine home ranges (Douglas-Hamilton 1975, Viljoen 1989). In Asia, particularly in India, a similar method was used by Sukumar (1985, 1989a, 1989b); Easa (1988), Daniel *et al.* (1987); and Desai (1991). Coloured collars (Daniel *et al.*, 1987), coloured and notched radio-collars (Dunham 1986), body painting (Jones 1975, Rodgers and Elder 1977) were also used in the study home ranges. The most successful method, according to several studies, is radio-telemetry. In Africa, this method was used by Leuthold and Sale (1973), Leuthold (1977), Douglas-Hamilton and Douglas-Hamilton (1975) and Dunham (1986). In Asia, this has been used by Olivier (1978) in Malaysia and by Desai (1991) in India.

**The present study:** The data on home range of elephants for this study was gathered between 1989 to 1992. Radio-telemetry, though a better method, was not employed in this study because of the unfavourable cost/benefit ratio. The elephants of the study area, due to their constant interaction with people, had good chances of getting killed, especially in the migration range in the state of West Bengal. This would have defeated the purpose of collaring. Another important point was, in fragmented areas it was not difficult to locate the elephants, once they were out of the forests. Therefore the home range values calculated using radio-telemetry data and visual resighting data would not show a significant difference in fragmented areas as it does in areas having vast stretches of forest. However, sightings within the Sanctuary had limitations because of the visibility and the home range size could be underestimated in such situations, for seasonal ranges. A considerable amount of time is used in locating the herds, due to the terrain and undergrowth and the inherent problem of identifying the herd and then the required

individual. This can be definitely avoided in radio telemetry.

For the present study, four identified elephants were selected for the home range estimation, of which 3 were adult males and one adult female. The female was named as Long Cut Ear (LCE), after the deep cut in her longish ear. The three males had human names : Arjun, Ganesh and Gabbar and were identified by their individualistic body characters. The elephants were tracked on foot, and a record of resightings, within the DWS and beyond in the migration and raiding ranges, was maintained. The sightings were maximum during the summer months followed by rains and Winter. The female (LCE) had her accompanying clan whose number varied from season to season, according to the number of family units joining or breaking away. [A clan is considered as a group of elephants having a coordinated movement and is believed to be related (Moss 1988).]

All the elephant resighting locations were digitized along with the map of the study area with the help of a digitizer pad attached to a computer. The locations were then analyzed and the home range sizes and the overlaps were calculated with the help of a software SEAS (Spatial Ecology Analysis System) developed by John Carey, Wisconsin University, U.S.A. All the home ranges were calculated using the Minimum Convex Polygon (MCP) method. Other methods- 95 % Ellipse and Harmonic Mean Transformation were also experimentally tried and compared. The choice of MCP over the other two is discussed in the results.

**Home range size:** Several techniques have been developed to analyze the home range of animals. All these techniques are divided into, based on statistical considerations, parametric estimators and non-parametric estimators. The best and the most extensively and popularly used non-parametric method, the Minimum Convex



Polygon (MCP) (Mohr 1947) is used here to estimate the size of individual home ranges and their overlaps, where the 'Convex' is defined as a figure having no inner angle greater than 180 degrees.

**Fidelity to home range:** The general pattern of home ranges was established by the end of the first year. The following years of observations were used to check the fidelity of the known individuals to the over all home range and the seasonal home range. The crop raiding areas were visited every year, around the DWS and the migration range in the state of West Bengal, to locate the identified individuals.

## RESULTS AND DISCUSSION

**Home range size:** The home ranges were estimated using the Minimum Convex Polygon (MCP) Method (Mohr 1947). The other two methods, 95 % Ellipse (Jenrich and Turner 1969) and Harmonic Mean Estimator (Dixon and Chapman 1980), were also tried but the calculated home range projections included areas like Jamshedpur town and other known non-elephant areas within their limits. Comparatively, the MCP method gave very logical results and the general axis of all the home ranges was close to what was permitted by the physical limits of elephant movement. The home range of the 4 individuals [3 males and 1

of individual years were not plotted as the number of sightings were inadequate. As such, all the migratory elephants, including three of the study individuals, have been expanding their home range on the eastern side, every year since 1987 till the end of the study in 1992. Therefore, the observation time-area curve could not reach an asymptotic value and did not flatten out.

However, the summer ranges did not increase significantly as the elephants stayed within the Sanctuary throughout the summer. In an area like DWS where elephants are moving out in search of a better habitat, possibly for colonization, the curve is not expected to stabilize till the elephants reach a suitable habitat or can not move further in any direction due to real physical barriers. The tremendous difference in the home ranges of the first and the last 3 animals (Table 1) is because the latter (Gabbar,

TABLE 1  
HOME RANGE SIZES OF THE STUDY ANIMALS

Study animal	No. of sightings	Area of Home range in sq. km using MCP	Unit
Arjun	41	258.60	Bull
Gabbar	39	3343.19	Bull
Ganesh	18	4348.99	Bull
LCE	31	3396.14	Clan

Ganesh and LCE) migrated every year to West Bengal during late rainy season, unlike Arjun who stayed back in Bihar, and raided crops

TABLE 2  
CALCULATED AND MAXIMUM SUMMER RANGES OF THE STUDY ANIMALS

Name of the elephant	Calculated summer range (MCP) in sq. km	Maximum possible summer range in sq. km	
		On sunny Days	On cloudy/rainy days
Arjun	23.75	35	55
Gabbar	28.27	35	55
Ganesh	04.54	35	55
LCE	22.67	35	55

female (clan)] were defined only for the study period of three and half years. The home ranges

locally, in and around the western part of Dalma Sanctuary. Arjun's home range size falls

within the home range sizes exhibited by study elephants at Mudumalai Sanctuary (Desai 1991) and by adult bulls in deciduous forests of eastern ghats (Sukumar 1989). The large overall home range sizes exhibited by the other three study animals are similar to those shown by elephants of Northern Namib Desert region of Kaokoveld (Viljoen 1989). Home range size normally varies with the habitat type. However, habitat condition and environmental factors may influence the home ranges to a considerable extent especially

crops only in the area surrounding the west buffer zone and the area southwest of the Sanctuary (Fig. 3). The 'Core area' of elephant usage was not estimated in this study. Similar studies in south India showed the 'Core area' to be 21.3% to 36.7% of the total home range, for the studied individuals (Daniel *et al.* 1992). In case of the migratory elephants this might be more than 75% of the total estimated home range. The LCE group and other family units migrating to West Bengal, all totalling about 45

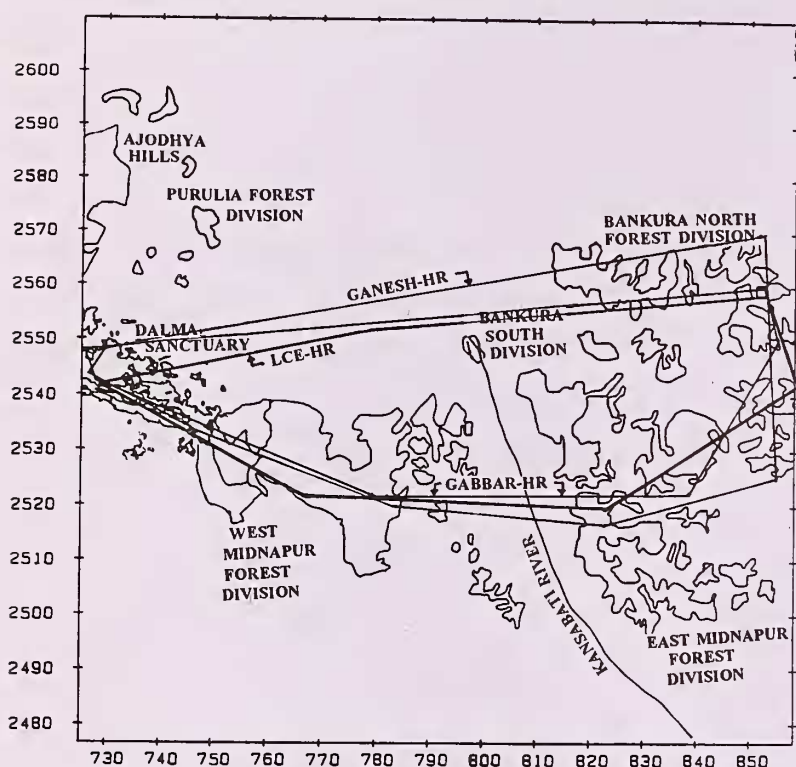


Fig. 2. Home range of elephants of Dalma Sanctuary (Ganesh, Gabbar, LCE, 1989-92).

in fragmented habitats.

Although the migratory elephants (Gabbar, Ganesh, LCE) did not show significant variation in the home range size, they utilized the area within the home range differently in different years. Fig. 2 shows the overall home range of these 3 individuals. On the left edge of the map is the Dalma Sanctuary. None of these 3 elephants ever used the western part of the Sanctuary (west buffer) or raided crops in the area to the west of DWS. On the contrary, Arjun utilized the western part (west buffer) and the core area of the Sanctuary extensively and raided

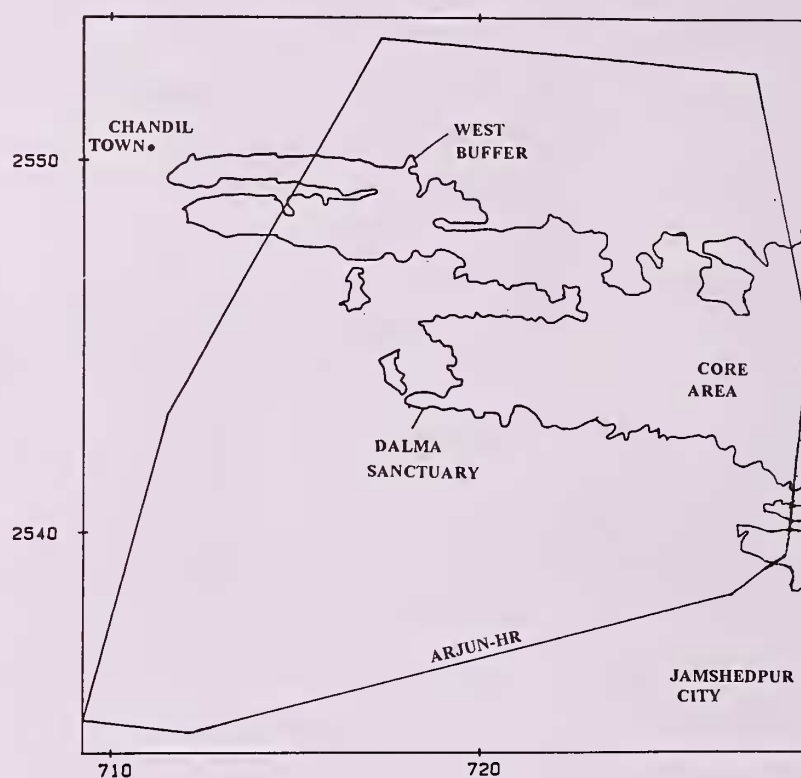


Fig. 3. Home range of elephant of Dalma Sanctuary (Arjun, 1989-92).

individuals, also showed similar home range patterns. One group of 12 individuals (two family units), that stayed back in Bihar throughout the winter and never migrated to the east, to Midnapur in West Bengal, but instead shuttled between the Sanctuary and the Ajodhya hill in Purulia district of West Bengal.

**Factors influencing home range size:** All the individuals studied showed seasonal variation in ranges. The summer ranges were the smallest (Table 2) for all the four individuals (Fig. 4).



This was because the Chhotanagpur Plateau has extremes of temperature and almost all waterholes in the buffer zones dry up. The high ambient temperatures force the elephants to take refuge in the Sanctuary core which is 55 sq. km in area. Of this 55 sq. km. only the northern slopes, which have an area of approximately 35 sq. km, are used on sunny days (most days of summer) as they are comparatively cooler than the southern slopes (Table 3) and hold most of the big waterholes. So effectively elephants were contained in an area of approximately 35 sq. km throughout summer.

TABLE 3  
AVERAGE TEMPERATURE AT NOON ON THE  
DALMA SLOPES IN SUMMER

Name of the Location	Slope	°C in open	°C in shade	°C in water
Majhla bandh	North	46.2	40.4	28.7
Nichla bandh	North	47.6	35.4	26.2
Aamdadi	North	45.6	33.4	22.9
Bijli ghati	North	40.2	31.3	28.4
Snan ghati	North	43.5	34.8	29.9
Ghusi jharna	North	42.0	38.8	26.0
Aamda Pahadi	South	50.8	32.6	26.6
Megha doha	South	55.9	39.7	28.5
Chagal Topa	South	49.7	36.9	27.9
Nutandih	South	56.7	49.7	27.7
Bhelatal	South	51.1	40.1	dry

They visited the southern slopes of the hill during night only sporadically when there was no forest fire, as the exposed rocks on the southern side gave out heat during the night, and forest fires only added to the ambient temperature. So the maximum area of the summer range could be 55 sq. km, if one includes the southern slopes where the elephants made forays only during the summer showers or overcast conditions with cool winds blowing. Moreover, there were more number of water holes on the northern slopes than the southern

slopes. Due to the low tree density on the southern slopes, there was generation of 'gaps' in the forest canopy, which reduced the total available shade. The bigger the gap the greater the solar radiation on the forest floor and the greater the changes in the other facets of microclimate above and below the ground, from conditions beneath the closed canopy. Wien (1985) recorded the microclimatic (temperature) difference and its influence on the birds and mammals that showed a marked preference of study animals to low direct radiation areas in the extreme climate. The daily variation in the

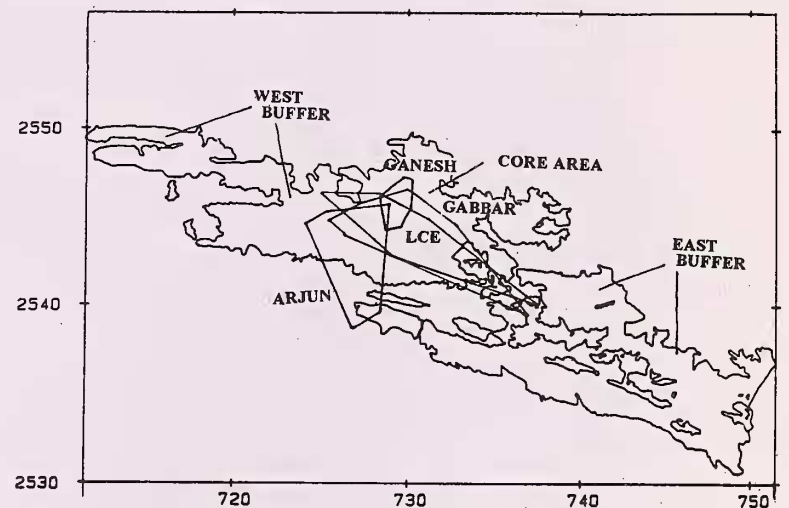


Fig. 4. Summer range of elephants of Dalma Sanctuary (Arjun, Gabbar, Ganesh, LCE, 1989-1992).

ground temperature is much higher in denuded areas compared to the land under forest. Studies in Singapore revealed higher temperatures at all depths from 3 to 50 cm in the bare soil, slightly less under grassland and lowest and the least variable under forests (Meher-Homji 1991). The forest fires were more common on the southern than the northern slopes due to low humidity on the former as a result of low tree cover and relatively high grass cover adding to overall surface temperature.

The summer ranges of Arjun, Gabbar and LCE did not differ significantly, however, summer range of Ganesh differed significantly from the other three. The small summer range of Ganesh could be because of the territoriality of

the Big Bulls Arjun and Gabbar (both 35+ age class), who came into musth during the summer months. Ganesh being of a younger age class (18-20) was probably keeping away from the big bulls in the small core area.

A study in the Mudumalai Sanctuary showed that the musth range of the adult bull overlapped most of the area of its total home range (Daniel *et al.* 1992). The musth ranges of the adult bulls studied during the present investigation also overlapped and were very small. However, this was not a problem because all the adult females in oestrous were present in the same area.

This small area of 35-55 sq. km was the only place that offered food to the elephants during the entire summer. The forest area was exploited by the elephants to the fullest as there was little in the agricultural lands around the sanctuary to supplement their forest diet. At the end of summer the elephants were in run-down condition possibly due to low availability of quality food due to over exploitation of forest resources. At the onset of the rainy season, the temperature on the southern slopes dropped due to the cloud cover, and elephants immediately moved to the southern slopes to exploit whatever grass that was available and also other food tree species. The bulls moved down to the edges of the forest as the monsoon progressed and started raiding paddy. At this point the home ranges started expanding. The rainy season ranges were not calculated due to lack of sufficient sighting locations but could be roughly estimated to be around 150-200 sq. km. Arjun moved westward of the Dalma Sanctuary after the initial forays on the southern fringe of the sanctuary; whereas Gabbar, Ganesh and LCE expanded their ranges on the east, from July onwards.

**Fidelity to home range:** The three study animals (Gabbar, Ganesh, LCE) were located in

the same areas of the western part of their home range in the succeeding years (summer and rain range in Bihar). The winter ranges were expanding throughout the study period and between the years the locations in the migration range (winter range) though lying in the same area changed localities. The reason for this, in case of the three migratory animals was that probably the herds and the bulls were chased randomly by the people and the officials of the forest department and hence could not reach the same locality every year in West Bengal, although the general area of visit was same. Arjun and a family group visiting Ajodhya hills, maintained absolute fidelity to their home range in the western part of the Sanctuary. In Bihar, the elephants were not chased as they were in West Bengal and this was one of the reasons for their fidelity to the home range. Gabbar, Ganesh and LCE never visited the western part of the sanctuary that includes western buffer of Dalma Sanctuary. In fact other family units associated with LCE also never moved to the western buffer throughout the study period. Similarly Arjun and a family group that stayed back in Bihar (not included in this home range study) never visited eastern part of Dalma Sanctuary. Thus even in the face of extreme degradation and fragmentation (Datye 1993) these study animals maintained fidelity to their home ranges. It will be interesting to see what happens to home ranges of such animals when the sanctuary is totally unable to support them in future due to loss of vegetation cover and food species.

**Axis of the home range and linear expansion:** The home range of all the elephants migrating to West Bengal showed a NW-SE axis to their home range. Arjun showed NE-SW axis and the Ajodhya group showed a N-S axis. The linear expansion in home ranges is shown in Table 4. The linear expansion difference was statistically insignificant between the years 1988



and 1989 but the differences in linear expansion between 1988 and the years 1990, 1991 were

but also point to the fact that the present area of the sanctuary may be a fragment of what was

TABLE 4  
LINEAR EXPANSION IN KM OF HOME RANGES OF THE STUDY ANIMALS

Direction	1988*	1989	1990	1991	Extreme
East	83	113	137	143	250
West	-	06	05	06	06
North **	-	21	26	24	26
South	-	0	0	0	0

\* Past record of the Forest Department.

\*\* Ajodhya hill family group not included in the home range estimation due to lack of sufficient observations. However, Linear expansion is based on the report from the northern most point of their visit.

statistically very significant.

The expansion of the home range on the west and north side is insignificant probably because elephants went to these areas only for crop raiding and not for exploration of a suitable habitat. On the other hand, the elephants expanded their home ranges considerably on the east, for exploration and search for a better habitat in the face of rapid degradation of the DWS, as an extension of their traditional seasonal range to east of the Sanctuary, in the west Midnapur area. Such a traditional seasonal range apparently did not exist in the west of DWS. The migrant population obviously had a different strategy than the resident Bihar population.

**Home range overlaps with Sanctuary:** All the study individuals showed that a very significant part of their home ranges lies outside the DWS. Arjun had 77.29%, Gabbar had 96.95%, Ganesh had 97.47% and LCE 96.45%, overlap on the agricultural areas outside the Sanctuary. Even if the agricultural overlap, calculated using MCP method, is considered to be much more than the actual area of usage, the area of the Sanctuary overlap would be less than that of the agriculture. These overlaps indicate not only poor carrying capacity of the sanctuary

once the original habitat of Dalma elephants that has come under human encroachment.

The knowledge of home range of elephants in fragmented areas thus throws light on the real utility of such 'fragments', termed as sanctuaries in many places, to the elephants and could be used in knowing the preferred areas of elephants, for better management.

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